Synthesis of Ni nanoparticles by dc magnetron sputtering

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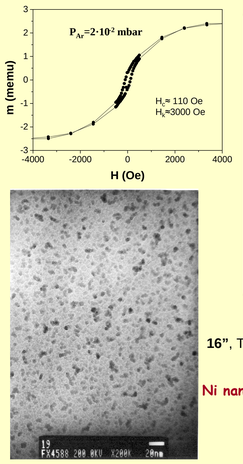
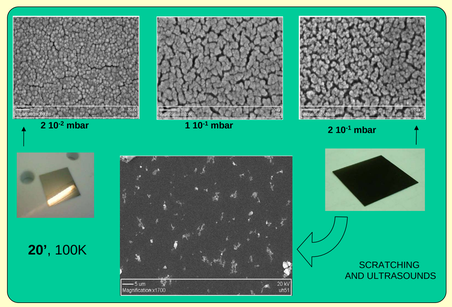
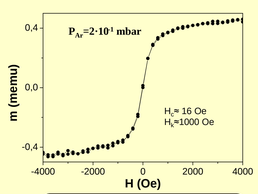
ABSTRACT

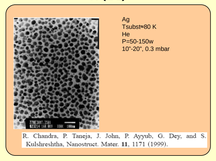
Magnetic materials have been used with grain sizes down to the nanoscale for longer than any other type of material. The biomedical applications cover from magnetic separation of specific biological entities from their native environment to drug delivery, hyperthermia treatments or MRI contrast enhancement [1]. There are many synthesis methods depending on the final applications of the magnetic nanoparticles [2]. Sputtering methods are less extensively used, maybe due to the low efficiency of the process, however these methods have the advantage of a good control on the composition and size of the particles. Research has focused mainly on Fe [3,4], Co [5] and FeCo alloys [6]. In this work we apply the dc magnetron sputtering technique to the growth of Ni nanoparticles.

DIRECT GROWTH



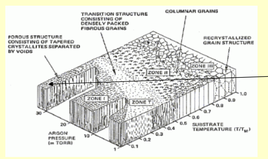






16", T=100K, 0.1 mbar

Ni nanoparticles (~4nm)

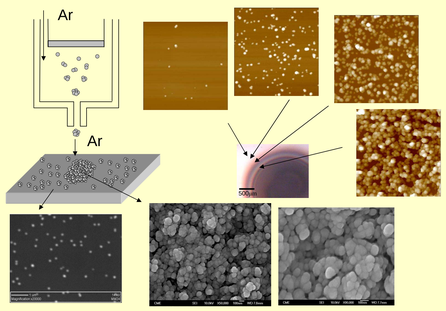


POROUS STRUCTURE CONSISTING OF TAPERED CRYSTALLITES SEPARATED BY VOIDS

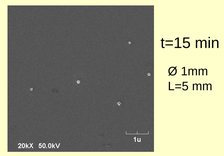
J.A. Thorton, J. Vac. Sci. Technol., 11, (1974), 666

High Ar pressure promotes the formation of nanoclusters that are deposited on a low temperature substrate growing a dark and highly porous thin film.

PARTICLE GUN (larger size)

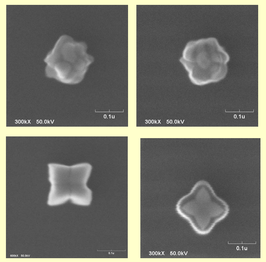


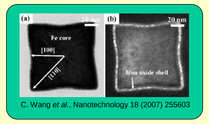
Nanoparticles distribution on the substrate .



t=15 min

Ø 1mm
L=5 mm



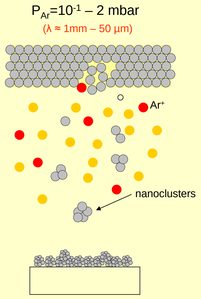


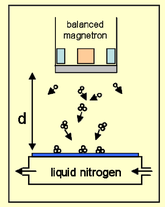
HR-SEM images of nanoparticles grown with 1 mm nozzle diameter. Their size is about 150 nm and some of them appear as aggregates of smaller particles (up), while others look like small crystals (down).

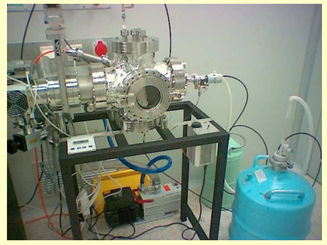
The increase in the temperature of the chamber at the end of the growing appears high enough to make some particles have a crystal structure.

EXPERIMENTAL

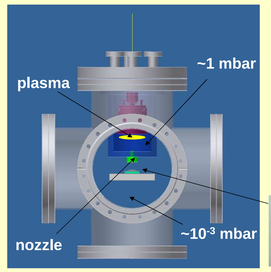
Direct growth

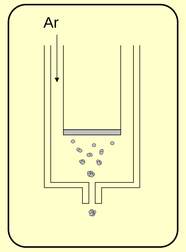






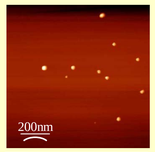
Particle Gun





0.6 mbar

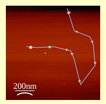
PARTICLE GUN (small size)

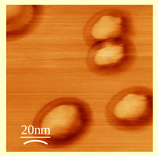


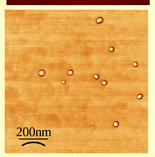
Height ~ 9-14.5 nm

P_{Ar}=0.4 mbar

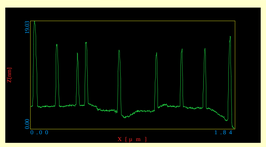
height



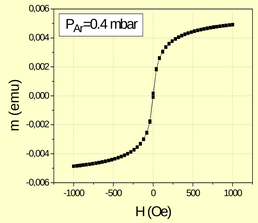


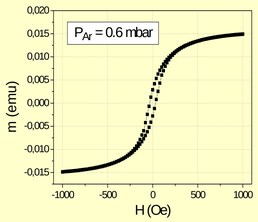


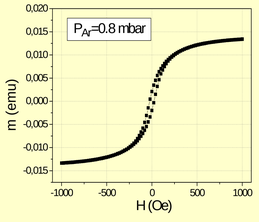
phase



Ø 2 mm
L= 20 mm



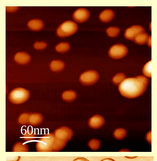


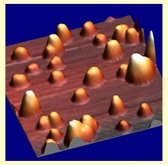


Height ~ 9-20 nm

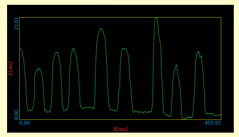
P_{Ar}=1.6 mbar

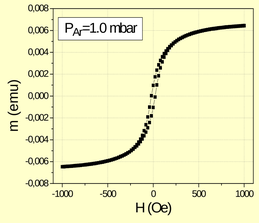
height

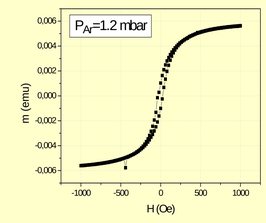


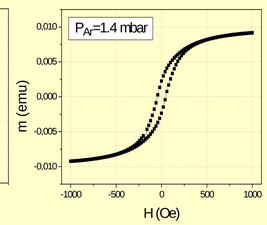


phase









Morphology and magnetic behaviour as a function of Ar pressure in the aggregation chamber.

Acknowledgemets: AFM pictures shown and processed by WSxM (Nanotec Electrónica S.L.)

CONCLUSIONS

- In the case of direct growth, Ni thin films obtained at high inert gas pressure are dark, weakly adhered to surface and can be easily scraped-off, but surface aggregates cannot be easily broken into single particles.
- With the particle gun configuration, we are able to grow well isolated particles with different sizes that depend on the nozzle diameter. We have tried both 1 and 2 mm diameter, and we have obtained nanoparticles around 100 nm and below 20 nm respectively.
- Two different kind of particles have been observed: small crystals and clusters.

REFERENCES

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[3] P. Shah, A. Gavrin, J. Mag. Mag. Mat 301 (2006) 118
[4] A. Sharme, Y. Qiang, J. Antony, D. Meyer, P. Kornacki and A. Paszczynski. IEEE Trans. on Mag. 43 (6) (2007) 2418
[5] Y.H. Xu, J.P. Wang, IEEE Trans. on Mag. 43 (6) (2007) 3109
[6] Y.H. Xu, J. Bai, J.P. Wang, J. Mag. Mag. Mat. 311 (2007) 131